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AIR TRAFFIC DELAY STUDY GROUP REPORT, CENTRAL REGION.(U)  
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<sup>6</sup> **AIR TRAFFIC DELAY STUDY GROUP**  
**REPORT, LEVEL II** ①

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ST. LOUIS TOWER AND KANSAS CITY CENTER  
FEDERAL AVIATION ADMINISTRATION-CENTRAL REGION  
REGIONAL OFFICE- 601 EAST 12th STREET  
KANSAS CITY, MISSOURI 64106

412371

#### ACKNOWLEDGMENT

The Facility Chiefs at the St. Louis Airport Traffic Control Tower and the Kansas City Air Route Traffic Control Center would like to thank Mr. Raymond Blanc of the Control Data Corporation for his valuable assistance and support in the development of this study. We also want to express our thanks to Mr. Glenn A. Bales, St. Louis Airport Traffic Control Tower, and Mr. Charles Bumstead, Kansas City Air Route Traffic Control Center, for their significant contributions in the development of this study and preparation of this report. Other study group members deserving special acknowledgment are Ricky Baird, St. Louis Airport Traffic Control Tower, and Michael Brown, Kansas City Air Route Traffic Control Center.

ATF-1

**DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION**

DATE: MAY 14 1980  
IN REPLY REFER TO: ACE-535

CENTRAL REGION  
601 EAST 12TH STREET  
KANSAS CITY, MISSOURI 64106



SUBJECT: Air Traffic Delay Study Report, Central Region

FROM: Director, Central Region, ACE-1

TO: ATF-1, AVS-1, AAT-1, AAF-1, ARP-1

Enclosed is a copy of the recently completed Air Traffic Delay Study Report developed by St. Louis Tower and the Kansas City Center.

Due to several factors, which include increased traffic and enroute traffic flow restrictions, arriving and departing users of the St. Louis Airport have experienced increasing delays. The hourly traffic count at St. Louis-Lambert has increased considerably with a projection of further increase. American Airlines plan to double their daily operations and Eastern, Trans World and Ozark have announced plans to increase flight operations during the coming year.

In view of these projections, St. Louis Tower and Kansas City Center were asked to collectively develop a working group, consisting of facility officers, staff, supervisors and controllers. The working group concerned themselves with existing constraints and projected resources necessary to accommodate future traffic demands. This report is the result of those efforts by the working group.

We plan to request comments from aviation users and user groups beginning May 30, 1980. Should changes prove necessary as a result of these comments, the plan will be amended accordingly. We would be pleased to provide a Washington Headquarters briefing at your request. Copies of this report have been furnished to the Administrator and the Southern and Great Lakes Region Air Traffic Divisions.

If you wish further information regarding this report, please contact me or William Pollard, Central Region, Air Traffic Division Chief, FTS 758-5207.

*Paul J. Baker*  
PAUL J. BAKER

Enclosure

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FORWARD

This Delay Study Report was prepared jointly by the St. Louis Airport Traffic Control Tower and the Kansas City Air Route Traffic Control Center for the Air Traffic Division, Federal Aviation Administration, Central Region. The contents of this report reflect the views of the respective Facilities, which are responsible for the fact and the accuracy of the data presented herein, and does not necessarily reflect the official views or policy of the Federal Aviation Administration, Central Region. This report does not constitute a standard, specification or regulation.

DON D. EARLY  
Chief, St. Louis ATCT

REX K. McQUEEN  
Chief, Kansas City ARTCC

Accomplished	X
Reviewed	
Approved	
Dated	
Initials	A

STUDY GROUP PARTICIPANTS

Glenn A. Bales (Co-Chairman)  
Deputy Chief, St. Louis Tower

Ricky Baird (Team Leader)  
Team Supervisor, St. Louis Tower

Brian Pantle  
Air Traffic Control Specialist  
St. Louis Tower

Thomas O. Mathison  
Air Traffic Control Specialist  
St. Louis Tower

Thomas Davidson  
Air Traffic Control Specialist  
St. Louis Tower

Charles Bumstead (Co-Chairman)  
Deputy Chief, Kansas City ARTCC

Michael Brown (Team Leader)  
East Area Specialist, Kansas City ARTCC

Richard Gibson  
Team Supervisor, Kansas City ARTCC

Herman Thomas  
East Area Officer, Kansas City ARTCC

Vernon Vaubel  
Flow Controller, Kansas City ARTCC

Jerry Mann  
Regional Director, Chicago Regional Office  
Air Transport Association

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### PREFACE

This study of air traffic delays in the St. Louis Terminal-Kansas City Center East Area, its causes and potential solutions, has identified no panacea to the problem in the present or future. However, the study does outline a comprehensive program of delay reduction measures which if implemented, has the potential to dramatically reduce the current level and costs of delay. The program will also provide significant future delay reduction benefits regardless of the future air traffic control environment. The potential cost savings outlined are not intended to represent absolutes but rather to point out the most productive directions in which to focus industry action.

The study was conducted from September 1979 through March 1980 by a group composed of representatives of the St. Louis ATCT, Kansas City ARTCC and Air Transport Association.



## I N T R O D U C T I O N

This Executive Summary of the St. Louis Airport Traffic Control Tower and the Kansas City Air Route Traffic Control Center Traffic Delay Study represents an evaluation of the complex interactions between aircraft demand, facility and equipment configurations and air traffic control management procedures which result in the air traffic control system's ability to process aircraft effectively.

## B A C K G R O U N D

Since the introduction in the early 1970's of the heavier, wide-bodied aircraft with their attendant wake vortex problems, airfield capacity has been steadily reduced at the nation's major airports. Coupled with the wake vortex problem is the ever-increasing volume of traffic. The effect of the increasing volume and the reduced airport capacity has been compounded by the rapid escalation of aviation fuel prices resulting in significant increases in the cost of aircraft operation. Environmental pressures following the enactment of the National

Environmental Policy Act of 1969 have virtually negated the development of new metropolitan airports to augment system capacity and have made the incremental expansion of existing facilities difficult at best.

It has become increasingly clear that continued provision of *satisfactory* air transportation service will require the industry to concentrate its efforts on maximizing the efficiency of the existing airport system, a fact supported by information brought out in the 1973 President's Aviation Advisory Commission report on the national aviation system.

Faced with rapidly escalating aviation fuel prices and with increasing numbers of wide-bodied aircraft with direct operating costs upwards of \$30 per minute, the aviation industry recognizes the need for quantitative system performance data on which to base tough management decisions on scheduling strategies, facility and equipment expenditures, and research and development priorities. To provide such system performance data, this study was undertaken by the Federal Aviation Administration,

with general input from the Air Transport Association (ATA).

The increasing incidence of air traffic delay reports provided evidence that St. Louis-Lambert Airport has been affected by the above mentioned events.

St. Louis-Lambert Airport is experiencing significant delays. The St. Louis Tower operational log for July 26, 1979, shows 82 aircraft delayed in excess of 30 minutes, with a maximum delay of one hour and five minutes. The volume of total aircraft operations correlates closely with the level of delay reports; the number of reports being highest at those times when the total operational volume is the greatest.

The Federal Aviation Administration Report on Airport Capacity reported that, "Reported cases of these delays indicate that 89 per cent are attributable to weather related problems. . . the majority of severe delays are weather related and are largely unavoidable." There is reason to question the report if, in fact, such delays are "largely

unavoidable" or rather result from a series of factors (many controllable, such as the number of aircraft in the system) which, when triggered by weather or other problems, compound into a severe system problem.

This study focused on the problems within the Kansas City ARTCC East Area airspace below 18,000 feet MSL and within the St. Louis Approach Control Area. A brief description of the IFR control facilities involved are as follows:

#### Kansas City Air Route Traffic Control Center

Kansas City Center supervises and controls all IFR traffic and other air traffic facilities in portions of nine states--Missouri, Kansas, Oklahoma, Iowa, Illinois, Colorado, Nebraska, Texas, and Arkansas, which covers an area of approximately 181,000 square miles in the central portion of the United States.

Of the twenty-five Air Route Traffic Control Centers operated by the Federal Aviation Administration in the United States and its possessions, Kansas City Center ranks thirteenth in total aircraft handled (in excess

of 1,439,000 operations annually) and ranks sixth in overflights-- that is, flights which totally traverse the Center's airspace.

The airspace is divided into thirty-four sectors to evenly distribute the workload and to provide for the safe, orderly, and expeditious movement and control of air traffic.

Operational staffing plus the computer, administrative and supervisory personnel gives the Center a total complement of 636. This number includes 271 highly trained air traffic controllers, 129 developmental controllers and 57 electronic technicians.

ATC clearances are issued to 30 towers, 19 flight service stations, and numerous airline dispatch offices for relay to aircraft operating from 314 public-use airports in its area, or to approximately 1,460 departures per day. During poor weather conditions, peak day departures often exceed 2,100 with total operations exceeding 5,700 aircraft during a 24-hour period.

Eleven military bases, including Military Airlift Command Headquarters, are also within the control jurisdiction of the Kansas City ARTCC.

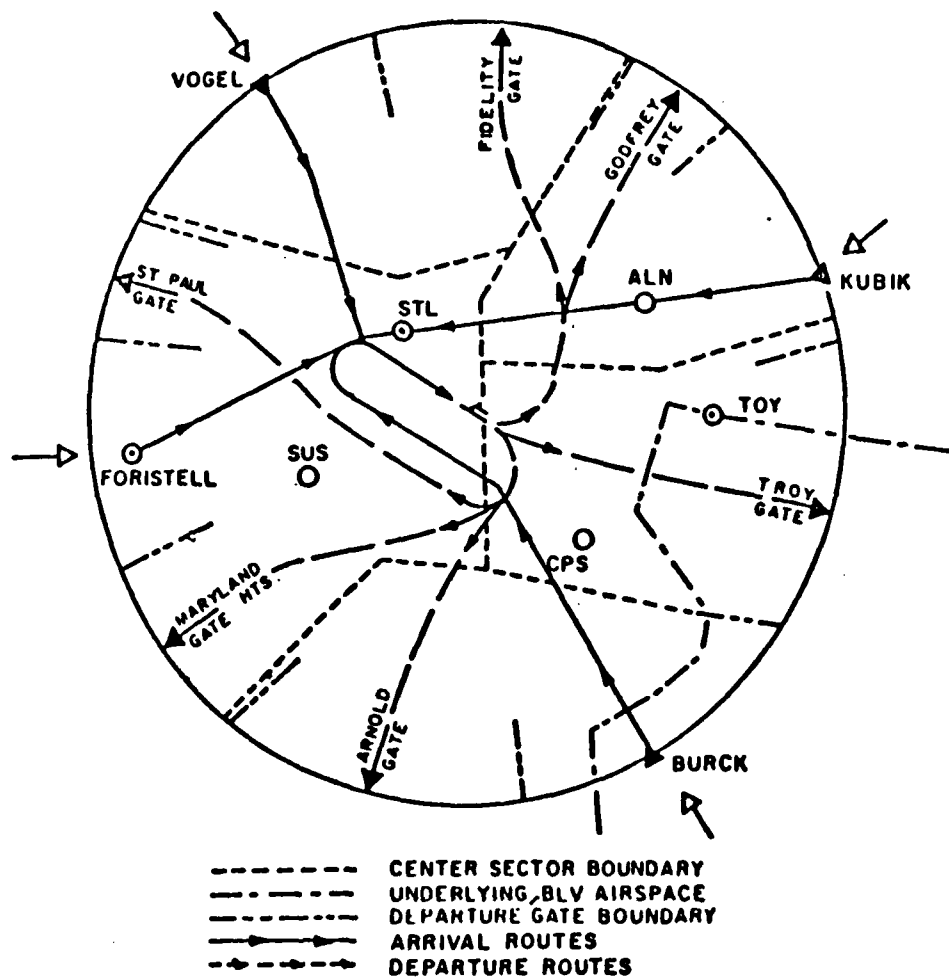
#### Approach Control

St. Louis Approach Control has been delegated airspace for the control of IFR traffic within a 32 nmi radius of the St. Louis ASR from the surface up to and including 12,000 feet (Figure 1). There are nine satellite airports under the St. Louis jurisdiction:

Civic Memorial  
Bi-State Parks  
Weiss  
Spirit of St. Louis  
Arrowhead  
Creve Coeur  
St. Charles Municipal  
St. Charles Smartt  
Washington Memorial

Eight of the nine satellite airports are located beneath the floor and within the lateral limits of the St. Louis Terminal

FIGURE 1



#### Control Area (Group 2).

The St. Louis delegated airspace is functionally subdivided to balance workloads, reduce complexity and to meet user demands. Subdivisions are normally northeast/southwest of runway 12R/30L extended centerlines, below the floor of the TCA and/or 5000' whichever is lower, and above 5000' through 12,000 feet.

Turbojet and turboprop arrival aircraft above 6000 feet are routed via one of the four corner posts (Figure 1), thence along a pre-defined corridor to an approach or descent quadrant. Propeller driven aircraft arriving St. Louis below 5000 feet are vectored by Low Altitude Control and normally given an approach to a secondary runway. Low Altitude Control also accommodates the satellite operations, which includes practice approaches at satellite airports.

Departing aircraft are vectored through departure gates (Figure 1) that are appropriate for the

direction of flight. As in the case of arrivals, turbojet and turboprop aircraft remain above the floor of the TCA until exiting the lateral limits. The concept being applied is the segregation of high and low performance aircraft as much as practical.

Scott Air Force Base is located approximately 28 nmi southeast of Lambert-St. Louis International Airport. Traffic entering or exiting the Scott AFB approach area on a course from approximately 240 degrees clockwise to 020 degrees is handled by the low altitude function of St. Louis approach control. Radar handoffs are exchanged and communications transferred prior to reaching the common boundary. Pre-determined routes and altitudes are utilized for efficiency.

The increase of delays in St. Louis and Kansas City ARTCC East Area having become the norm and coupled with a planned increase in the aircraft activity, both through St. Louis and permanently stationed in St. Louis, has triggered this delay study.

The initial stages of the delay study has produced some direct problems to be dealt with on a short term basis as well as some long term solutions as listed below:

- (1) The completion of airport construction will greatly reduce delays.
- (2) Internal and external coordination must be improved.
- (3) Proposed Landing Directional Aid (LDA).
- (4) Research of center sector capacity.
- (5) Study center traffic flow.

(6) Strive to equalize arrival and departure delays.

(7) Consider revision of airway structure.

(8) Solicit services of a private consulting firm to study interaction between concerned centers and major hubs.

The delay study will be underway for several months and as the study progresses, new solutions/alternatives may be forthcoming. The overall system study objectives are listed below:

#### OBJECTIVES

Considering the background of escalating delays, with their cost implications, the Delay Study Group has agreed upon objectives to guide the analysis of St. Louis-Lambert Airport conditions. These objectives are:

1. To determine current system capacity and delay levels and to identify causes of aircraft delay associated with operations in the airspace system.

2. To determine the potential delay reduction benefits of alternate ATC procedural options in the current and future periods.

3. To determine the potential delay reduction benefits of proposed future ATC system improvements.

4. To determine relationships between ATC demand and delay in the current and future time periods as an aid in establishing acceptable air traffic movement levels.

5. To identify areas of potential capacity constraint in the St. Louis-Lambert Airport ATC system.

The scope of the study and methodology utilized to achieve these objectives are described in the balance of this summary.

#### SCOPE

All analyses focused on means for increasing facility operating efficiency and reducing delay through procedural adjustments, airport-use policy changes, and/or airport development actions. Analyses were primarily directed towards operations in the airspace/airfield system.

This study, focusing on internal facility operations and airspace constraints, is intended to supplement the FAA Headquarters sponsored Airport Improvement Task Force effort that is primarily dealing with Lambert-St. Louis International Airport as a single entity.

While environmental implications were recognized in developing recommendations, assessment of environmental impact was beyond the scope of the study. A current Environmental Impact Statement (EIS) for Lambert-St. Louis International Airport expansion has been prepared under the FAA Planning Grant Program and is being coordinated at the Department of Transportation level.

#### METHODOLOGY

The study was conducted using a simulation model which reflects the observed variability in system operations. This model was validated against real world throughput and delay data and then employed to quantify the benefits of the alternative delay reduction options identified by participants. A set of model input parameters was structured which characterized each option to be modeled. The results of the model experiments were then compared to

control or baseline experiments and the delay reduction potential assessed. Input data was gathered from ARTCC and terminal records (such as time of arrivals and departures), and published material (approach routes, restrictions, speeds). Some data was obtained from the airlines, such as gate utilization and on-time performance statistics. Certain data pertaining to arrival/departure spacing times (how closely can two aircraft land on the same runway) and runway crossing were obtained by observation and measurement.

Output is produced in tabular form for each hour of the day and totalled for the entire day. Data is produced for each sector and for each airport. Sector data is grouped by arrivals and departures. Airport data is grouped by landing, takeoff and crossing queues.

Data consists of demand (number of aircraft), number of aircraft handled, number left in the queue, and number of aircraft delayed. Delay times are given for total delay, average delay for all aircraft, and the maximum delay as experienced by any aircraft.

During the conduct of the simulation studies, an evaluation team was placed in the St. Louis Tower and Kansas City Center operating quarters to observe the operation and collect pertinent information that verified bottlenecks identified through simulation and that identified other delay problems.

A command post-type operation was established. The St. Louis Tower Cab, Tracon, and Kansas City Center were manned with observers fourteen hours a day for ten working days. Observation periods were from 7:00 a.m. to 8:00 p.m. As a delay situation began to unfold, observers, via a hot line, attempted to identify the situation impact and to determine the cause. Team leaders debriefed their respective teams daily and coordinated debrief with each other. When a need for more information on a particular area or a delay pattern developed, team leaders provided the appropriate guidance to their team, thus enabling them to zero-in a causative factor. At the conclusion of the simulation study and traffic delay survey, members of each group collectively reviewed the identified problems, potential resolutions, and developed appropriate recommendations for inclusion in a cost/benefit study for the development of action projects.



## KEY RECOMMENDATIONS

### air traffic operating strategy

- . Develop and implement an air-space reorganization plan which reduces complexity, bottlenecks - thus delay, and increases system capacity.
- . Install a coordination line between ZKC and STL for use in control of traffic volume.
- . Implement procedures to reduce separations when existing equipment indicates wake vortices are not a problem.
- . Assume ~~IFR control~~ of Scott Air Force Base air traffic area.
- . Develop training package to improve radar vectoring and speed control techniques.

### management of demand

- . Encourage aircraft under 12,500 lbs. to utilize reliever airports.
- . Assess the costs of changes in the level and distribution of

## **facility improvements**

demand as a basis for re-evaluation of airline scheduling policy and/or adoption of quota regulation.

- . Refine flow control procedures controlling St. Louis traffic under abnormal operating conditions in order to limit delays.
  
- . Implement specific physical improvements associated with parallel approach capability; i.e., LDA Runway 12L & 30R.
  
- . Provide St. Louis Tower access to ZKC long range radar information.
  
- . Authorize four (4) additional operating positions for St. Louis (3 arrival, 1 departure).

## **future atc technology**

- . Implementation of advanced equipment and procedures to achieve reduced intrail separation under all meteorological conditions which eliminate wake vortex impact.
- . Step-up efforts to provide workable automation aids to the controller in managing terminal traffic.

## **additional study**

- . Perform environmental impact assessment, where appropriate, of action items described in the study.
- . Airspace reorganization impact on user economics and adjoining ARTCC's traffic flow.
- . Airline scheduling practices, time of day and route.

## S U M M A R Y O F S T U D Y

### CURRENT SYSTEM PERFORMANCE

#### Observations

Weekly Summary 1-21/25-80

#### Tower

##### Scheduling:

Air carrier departure scheduling during the busier hours has a built-in delay factor. It produces a compacted volume at the runway which is physically impossible to accommodate without some aircraft experiencing a delay. The largest departure periods are 09001cl, 1400 and 1600.

##### Local control techniques:

Naturally, techniques vary from one controller to another; however, some of the negative techniques that were observed were:

- a. Missed gaps
- b. Excessive divergent heading between departures - as much as 50 degrees.
- c. Applying 2 mins. separation behind a heavy jet rather than 5 radar miles.
- d. Lack of full utilization of all available runways.

In other instances, the controller waited until the required separation existed before clearing the succeeding aircraft for takeoff, thereby ending up with excessive intrail spacing.

##### Ground control techniques:

- a. Lack of segregating departures at different runways.

It should be noted that with the increase in crossing runway configurations, there has been a substantial increase in crossing runways with taxiing aircraft. The required

procedure of coordinating runway crossings has produced (during heavy volume) an additional workload on both the ground and local controllers.

Taxiway blockage:

For some time, ATS has been parking NW and PA in front of TWA's hangar and blocking the back-door taxiway. This presents a restriction to ground movements and needlessly causes some delay to TWA and Ozark aircraft.

Local/ground control strip bays:

The physical placement of the strip bay and lack of additional strip bays at both the local and ground control positions tend to affect the efficiency of both positions.

When using two or three departure runways, the placement of the strips in the local controller's bay may cause some confusion. If there is a substantial number of strips in the bay he has to sort out the strips - even if they are segregated by

runway - and because of the low placement in the console, his attention is drawn downward - away from where everything is happening - out the window.

At the ground control position, the strips are aligned out of sequence and when someone calls for taxi, the controller has to scan the whole bay for the strips. When he has a large volume to taxiing aircraft, he must place his strips even lower on the console top and there is not enough room on the counter top to arrange a large number of strips. As a consequence, they tend to get jumbled up. Also, the ground controller's attention is diverted downward and not out the window.

Tracon

Approach Control:

At times, approach control is lacking in efficiency. This is primarily caused by controller techniques. There were numerous instances of

excessive intervals on the final. The primary reason for the excessive intervals was because of the application of poor vector techniques and lack of speed control. As a result, the final would be extended farther than it should be and to compensate the Center would enter the hold. At times the lack of utilization of 30R/12L parallel visual approaches would also cause the 30L/12R final to be extended.

There were also numerous instances of ZKC not complying with the 250kt/altitude restrictions at the outer fixes, primarily at FTZ. The aircraft would come in very fast causing a high compression rate in the "dump area", thereby causing the final to be extended rapidly.

#### Air Carrier Scheduling:

During high demand hours, an average of 70% of the demand is scheduled for and accommodated during the first half of the hour.

#### ZKC/ZID intrail restrictions:

Normally, at 0830 ZKC imposes a 15 mile intrail restriction on ZID over VIA-STL. The same ZID sector works the VIA-STL and STL-BIB-LEU traffic. To accommodate the arrival intrail restriction and resulting additional workload, ZID initiates a 10 mile restriction (240 and above) over BIB. O'Hare normally receives the same restriction on J-73 traffic.

At 1530-1700 local, ZID implements a 10 mile (fl. 240 and above) restriction over BIB to accommodate sector volume. Observers were told at one time it was to accommodate ORD J-73 departures. After checking with ORD, it was found there is minimal J-73 traffic during this period. ZID also imposes a 10 mile restriction on ORD J-73 traffic.

Weekly Summary 1-28/2-1-80

Tower

This week's summary is a repeat of last week with two additional items:

Crossing configurations:

Most of the week, the NW-NE wind prohibited a good crossing configuration for departures. However, when runways 30 were in use and the wind did allow the use of runway 24, it was not used.

When VFR and on runways 12, runway 6 was not used for departures because of low altitude arrival traffic for 12L. There was only one instance of the tower stopping the low altitude arrivals to accommodate a large volume of departures.

Snow removal:

During the day shift on 1-30, the snow removal operation went

smoothly; they concentrated all equipment on one area and coordination was accomplished through one vehicle. However, on the evening shift the operation became chaotic. They spread their equipment all over the airport and each truck attempted to talk to ground control. Eventually, the CIC opened another ground control position just to work the trucks. There was an excessive amount of runway crossings, frequent congestion and inattentiveness on the part of the drivers. There were two instances of trucks crossing the active runway without permission.

Tracon

There were two recurring items:

- a. Approach control inefficiency due to individual controllers running excessive intervals and general lack of good vector techniques and speed control.
- b. ZKC failed to meet either the crossing altitude or speed

restriction at the outer fixes. This resulted in a delay for aircraft because either STL would not accept the aircraft or ZKC reversed course on their own initiative.

Weather:

On the evening of 1-30, weather was the reason for the large number of delays. One factor that greatly contributed to the problem is the high RVR minimums for 30L, 12R and 6.

Supervisor coordination:

One problem that surfaced a few times is confusion on coordination between supervisors at STL and between STL and ZKC. A couple of examples are:

- a. Metering
- b. Flow control restrictions
- c. Lack of specifics on intrail restriction from ZKC.

Air carrier scheduling:

Majority of air carrier arrival demand is in the first half of the hour. Example:

0800-0900 70% in first half of hour

0900-1000 70%

1100-1200 70%

1300-1400 66%

1800-1900 89%

High/Low arrival balance:

Many times high performance arrivals are delayed because of the volume of low altitude (IFR/TCA) arrivals to the short runway. The high performance traffic is not given parallel visual approaches to the short runway because of the low performance traffic. Basically, the only time the low altitude traffic is delayed is when all aircraft are sequenced to one runway; otherwise, they are always vectored to the traffic pattern



without incurring any delay.

**Recommendations to STL Internal Items:**

1. Departure scheduling: Air carrier departure scheduling has long been part of the delay problem. The compacted demand is physically impossible to accommodate without some aircraft incurring a delay. Recommend this problem in the present system be stressed to air carrier operations so they can pass the information to their marketing people.

2. Local control techniques: This is a problem that the team supervisors must solve. Certain performance standards must be required for position certification and they must be carried through in the normal day-to-day job performance.

**Concentration items:**

- a. Missed departure gaps
- b. Decrease divergent departure headings.

c. Apply radar separation behind heavy jet rather than time.

d. Utilize all runways to maximum extent possible.

e. Apply anticipated separation to a greater degree.

3. Ground control techniques: Segregate departures at different runways as much as possible.

4. Back-door taxiway blockage: Require ATS to park NW and PA aircraft in areas that do not affect the movement of aircraft.

5. Local/ground control strip bays: Recommend pedestals be installed at both the local and ground control positions. These pedestals should have two strip bays, a pad area in the middle and a small light at the head of the board. The advantages of these pedestals are that they would provide separate strip bays for segregated departure strips and bring the data working area up to a more comfortable and efficient

height. These pedestals have been recommended in the Tower modernization program. However, the study group believes pedestals should be adopted as soon as possible.

6. Recommended procedure change: At present, the clearance delivery controller reads the clearance to the pilot and then places the flight data strip in the ground controller's bay. The pilot then calls the ground controller for taxi. During heavy demand periods, it detracts from the ground controller's function to have a large number of aircraft calling for push back and taxi. The ground controller then has to hunt through the large number of strips in the bay for the correct one.

To correct this problem, it is recommended that pilots call clearance delivery for taxi, the clearance delivery controller then places the strip on the ground controller's board and tells the pilot to monitor ground control. This procedure would reduce frequency congestion and the clearance delivery controller can meter

aircraft to the ground controller during heavy traffic. Also, the clearance delivery controller can write the taxi times on the strip during delay periods, thereby giving the supervisor a clear picture of impending delays.

7. Approach controller efficiency: Again, this is a problem for the team supervisor. Job performance standards must be met.

Concentration Items:

- a. Vector techniques (projection)
- b. Speed control
- c. Application of parallel visual approaches

8. High/Low performance arrival balancing: During periods of high performance arrival demand, hold the low performance TCA arrivals for a short duration. This would allow for a greater application of parallel visuals to both parallel runways with high performance aircraft. This procedure

could also be applied during periods of heavy departure demand.

9. Recommend a joint committee comprised of airport management, air carrier operations, and FAA/ATC personnel to develop snow removal procedures. This committee should develop priorities and operational procedures for an efficient snow removal program.

#### STL/ZKD DEBRIEFING

2/11-2/12-80

#### Recommendations:

1. Present ZKC philosophy reference arrivals is "first come-first served". Arrivals are metered accordingly. It is recommended the above mentioned policy/practice be discontinued and adjust the traffic flow to accommodate the largest number of aircraft in the system.

Example: When a rush develops over one or two fixes, the heavy fixes should be accommodated as much as possible and if need be, hold the light fixes.

2. ZID BIB intrail restriction: Recommend CECF research the validity of ZID restrictions. If restriction is valid, check with ZID and the users on the feasibility of stratifying Bib traffic at FL230 until past the problem area. Also determine feasibility of re-routing on a permanent basis.

3. FTZ arrival problem - high and fast: ZKC at times have a problem getting the aircraft down from high altitude because of various reasons. It may be advantageous for the FTZ crossing altitude and a speed restriction of 250 knots be published on the STAR.

4. ZKC meter position: There was common agreement that this is a problem area. Basic procedure is to meter aircraft, based on times, from the arrival fix to the runway. There is great disparity in the application and efficiency of this procedure. Recommend alternative methods or refine the present procedure. Suggest intrail spacing at all fixes until STL is no longer able to absorb aircraft and then hold at the arrival fixes. STL could then pull out of the hold at the arrival fixes.

5. ZKC initiate arrival fix balancing. ZKC would reroute some aircraft from one fix to another to accomplish a workload balance to the STL north/south approach controllers. Recommend fix balancing be accomplished

internally by STL.

6. STL/ZKC supervisory coordination: At present, the STL supervisors must coordinate with two to four different people at ZKC to accomplish different activities. Also, the STL supervisor doesn't have unique facilities to accomplish his coordination. At present, he must use the landlines at the Assistant Chief's desk. The STL supervisor should have separate facilities for his use. Also, STL/ZKC supervisory coordination should be accomplished with one supervisor at ZKC. This should be done with the East Area Supervisor and he can disseminate required information. Recommend installation of appropriate coordination lines.

### S I M U L A T I O N

The first objective was to determine the performance characteristics of the system. Capacity, throughput and delay were selected as performance measures. The initial finding was:

Airfield capacity is the maximum number of aircraft operations (takeoffs and landings) which may be processed, irrespective of delay, in a given time at an airport under specific conditions of:

- . airspace constraints
- . ceiling and visibility conditions
- . runway layout and use
- . aircraft mix
- . percent arrivals
- . exit taxiway locations
- . system variability.

Airfield capacity in this study is a calculated value expressed on an hourly and daily basis. Hourly airfield capacity is calculated for specific combinations of runways in use (called a configuration).

Airspace capacity is the maximum number of aircraft operations which may be processed simultaneously by a controller or group of controllers, in a given dimensional sector under specific conditions of

- . sector size
- . organization of traffic flow
- . sector flight time
- . aircraft operating speed
- . separation requirements
- . control effort

Airspace capacity is a calculated value determined by a validated mathematical model and is expressed in terms of instantaneous aircraft count. This capacity value is constantly measured against demand to determine sector entry and/or exit for each aircraft movement. When demand exceeds capacity, delays are recorded and updated until each flight is terminated.

Throughput is the number of aircraft operations that may be processed by a runway configuration given actual demand under a combination of the specific operating conditions. At practical operating levels, throughput is always less than capacity due to variations in volume and distribution of actual demand. Given identical demand, throughput varies between runway configurations according to the ability of the configuration to process demand.

The visual flight rules (VFR) and instrument flight rules (IFR) capacities for St. Louis-Lambert International Airport were determined by the Airport Improvement

Task Force to be 109 and 87 operations per hour, respectively. Throughput for STL on November 21, 1979 ranged from 48 to 70 operations per hour.

#### CURRENT DELAY REDUCTION OPTIONS

The findings related to evaluating the potential delay reduction benefits of air traffic operating strategy, demand management and facility improvement options clearly indicate there are alternative means to significantly reduce current aircraft delays at St. Louis. These options, if implemented, offer potential for continued benefit through the pre-1985 and post-1985 periods.

- . Experiment 1 - Simultaneous parallel approaches with departures segregated by runway for direction of flight. Runway 12L was assumed to 9000 ft. in length and could be utilized by all aircraft types.
- . Experiment 2 - Provided additional terminal departure control position to remove constraints on runway environment.
- . Experiment 3 - Increased Kansas City ARTCC Sector capacities 100%. Assumes traffic flow reorganization, sector stratification and

#### Current Potential Savings:

Daily Delay - 502 minutes

Annual Dollars - \$3,664,600

#### Current Potential Savings:

Daily Delay - 650 minutes

Annual Dollars - \$3,558,700

#### Current Potential Savings:

Daily Delay - 1617 minutes

Annual Dollars - \$5,902,050

realignment. This postulation also allows the quantification of air-space constraints upon airport capacity.

- . Experiment 4 - Divert category A & B aircraft to improved reliever airports. For the purpose of this experiment, Spirit of St. Louis Airport (SUS) is used as the major reliever airport since it appears to have the greatest potential and traffic forecast indicates 300,000 operations at SUS by 1990. Parallel runways are projected for SUS airport and are assumed to be in place.

- . Experiment 5 - Combination of Experiments 1 through 4.

Current Potential Savings:

Daily STL Airport Delays - 177 minutes

Annual Dollars - \$969,075

Current Potential Savings:

Daily Delay - 1,475 minutes

Annual Dollars - \$8,075,625

NOTE: Dollar estimates consider fleet mix and airborne/ground aircraft operating cost.



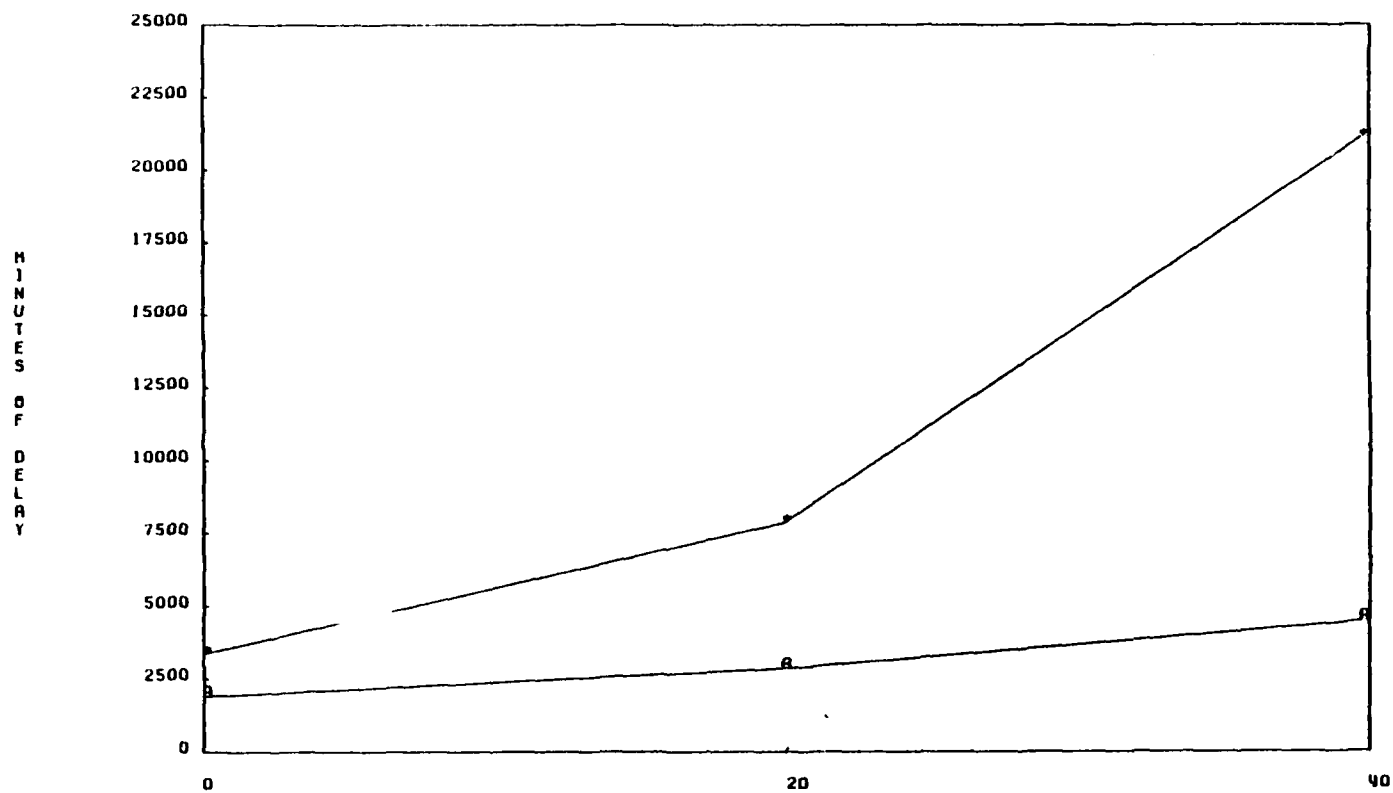
The relationship between system demand, system delay, throughput and airport delay; assuming no improvements to the present system with a 20% and 40% demand growth, was determined. This relationship shown in Exhibits 1 and 2 was then used as a baseline to quantify the degree of improvement for each and all proposed system improvements. Analyses of the throughput for arrivals and departures and their respective delay relationships indicate the largest system deficiency is handling departures. This deficiency is magnified with an increase in demand.

Delay is the difference between the actual time it takes an aircraft to perform an operation over a specific portion of the system and the normal time it would take to perform the same operation with no interference from other aircraft. A validated computer simulation was employed to calculate the delay characteristics of St. Louis Runway 12R/L configuration for various levels of demand. The calibration of the simulation

model to the Kansas City Center East Area environment was accomplished using the actual November 21, 1979 operational scenario. A comparison of the actual and simulated St. Louis throughput is shown in Exhibit 3.

Hourly computer snapshots were taken for three (3) levels of demand; present, 20% increase, and 40% increase. Effect of proposed improvements were then compared to each hourly demand - delay scenario. This information, reduced to graphical form, readily quantifies total and peak hour delay improvements (shown in Exhibits 4, 5, and 6).

ST LOUIS TOWER - KANSAS CITY CENTER  
DATA BASE NOVEMBER 21, 1979  
SYSTEM DELAY PROJECTIONS

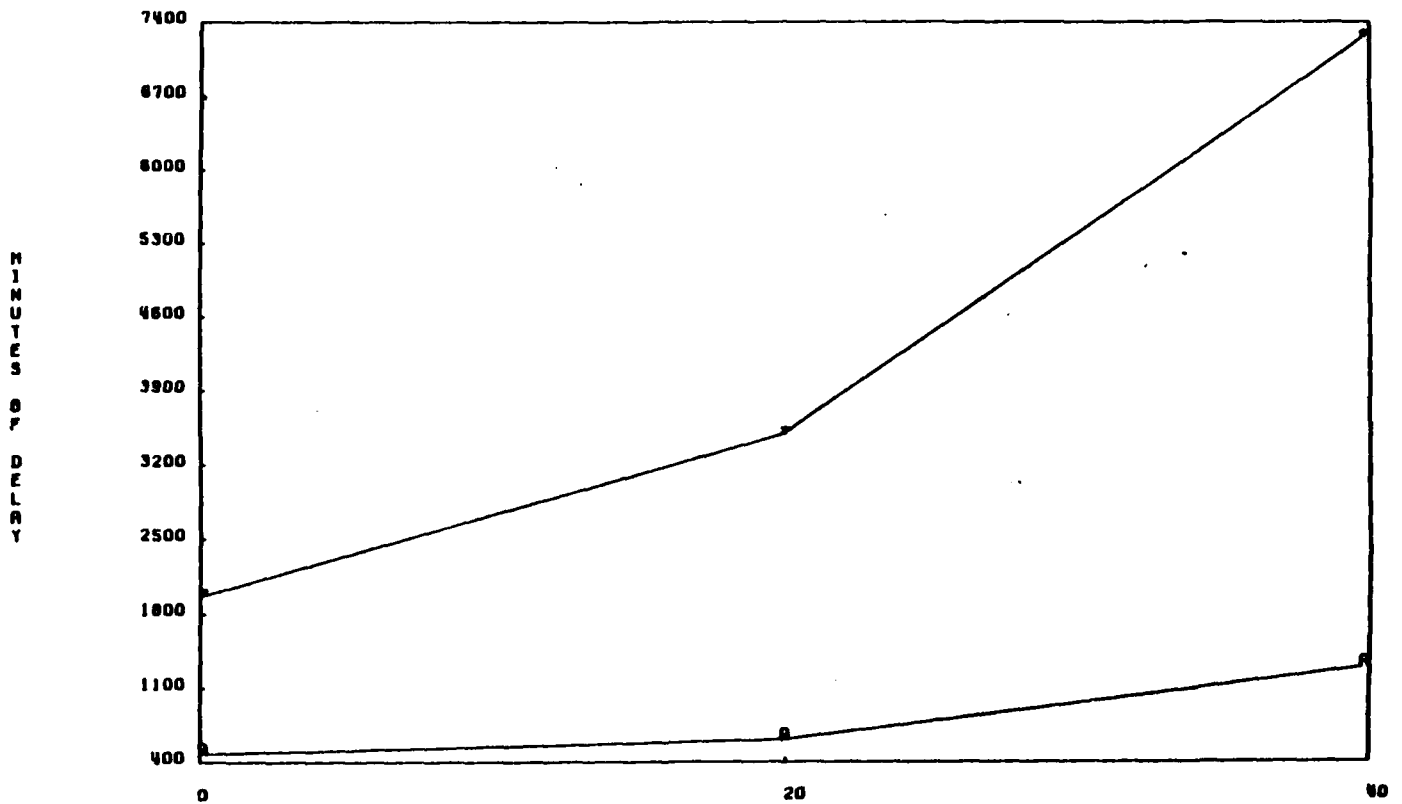


KEY FOR PLOTTING SYMBOLS  
 (S) -- PRESENT SYSTEM  
 (D) -- PROPOSED IMPROVEMENTS

DEMAND GROWTH  
 (IN PERCENT)

EXHIBIT 1

ST LOUIS TOWER - KANSAS CITY CENTER  
DATA BASE NOVEMBER 21, 1979  
STL AIRPORT DELAY PROJECTIONS



KEY FOR PLOTTING SYMBOLS  
101 -- PRESENT SYSTEM  
101 -- PROPOSED IMPROVEMENTS

DEMAND GROWTH  
(IN PERCENT)

EXHIBIT 2

ST LOUIS TOWER - KANSAS CITY CENTER  
 DATA BASE NOVEMBER 21, 1979  
 COMPARISON OF ACTUAL AND SIMULATED STL THROUGHPUT

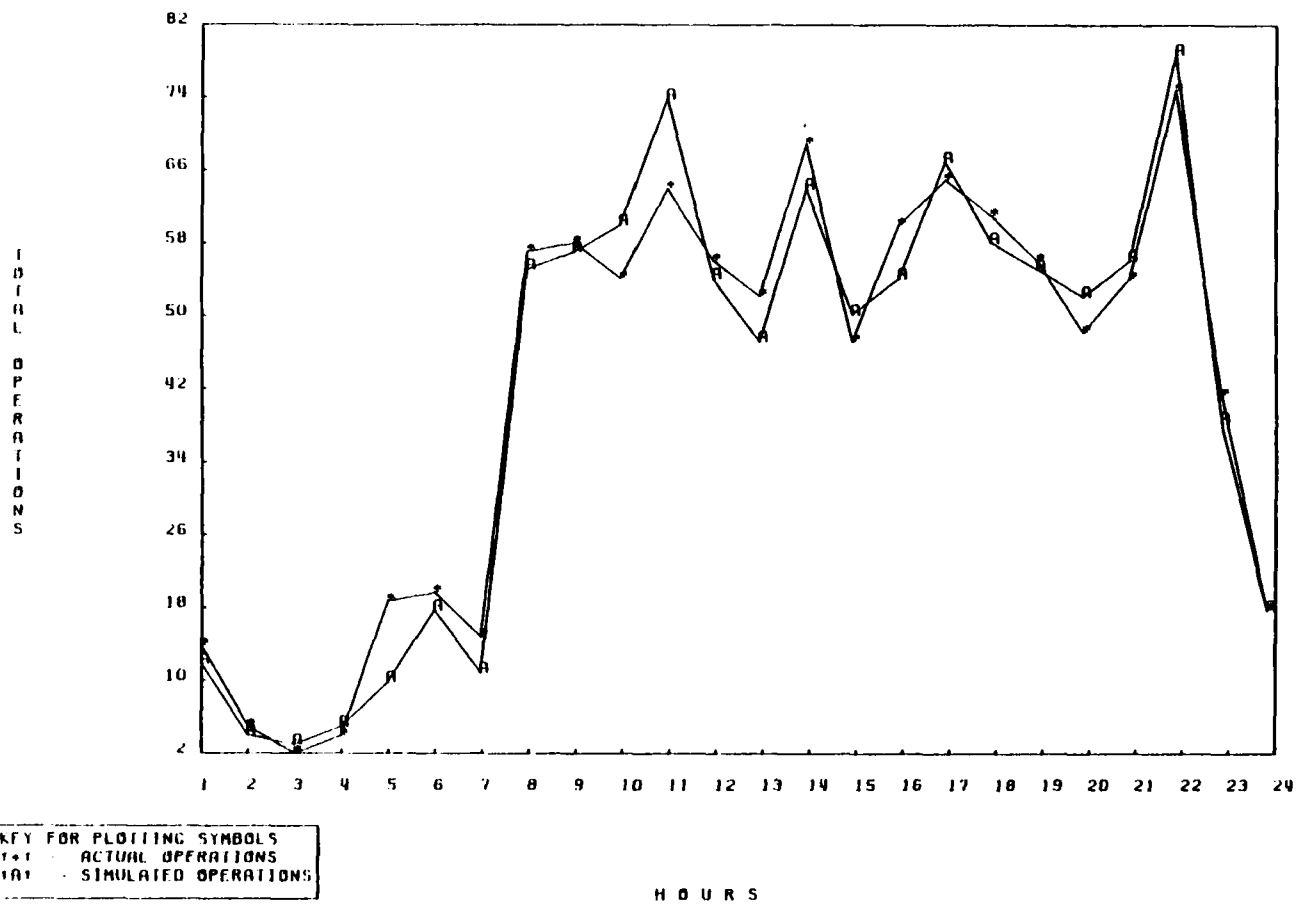


EXHIBIT 3

ST LOUIS TOWER KANSAS CITY CENTER  
 DATA BASE NOVEMBER 21, 1979  
 24 HOUR DELAY PROFILE - PRESENT DEMAND

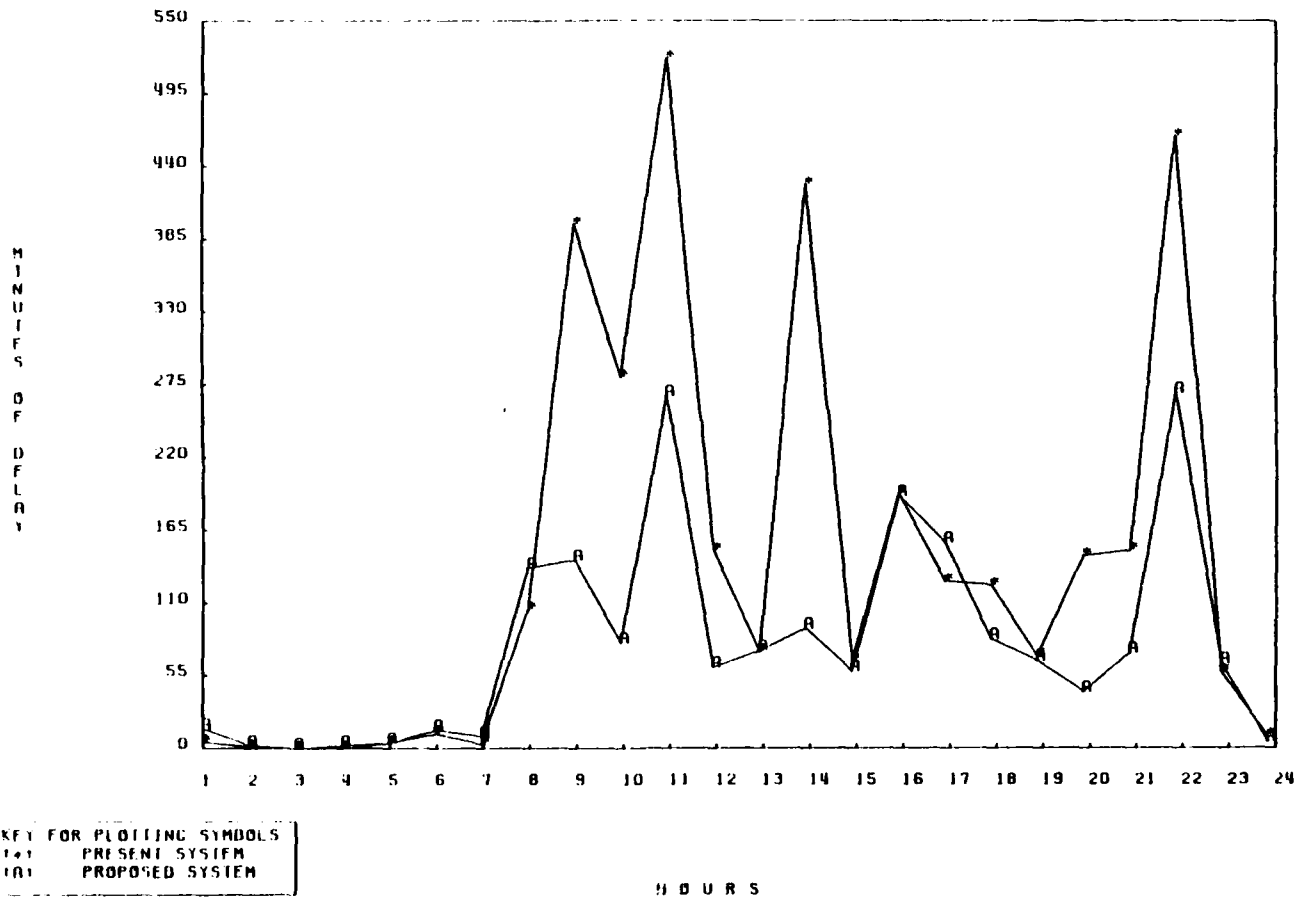


EXHIBIT 4

ST LOUIS TOWER - KANSAS CITY CENTER  
 DATA BASE NOVEMBER 21, 1979  
 24 HOUR DELAY PROFILE - INCREASED DEMAND 20%

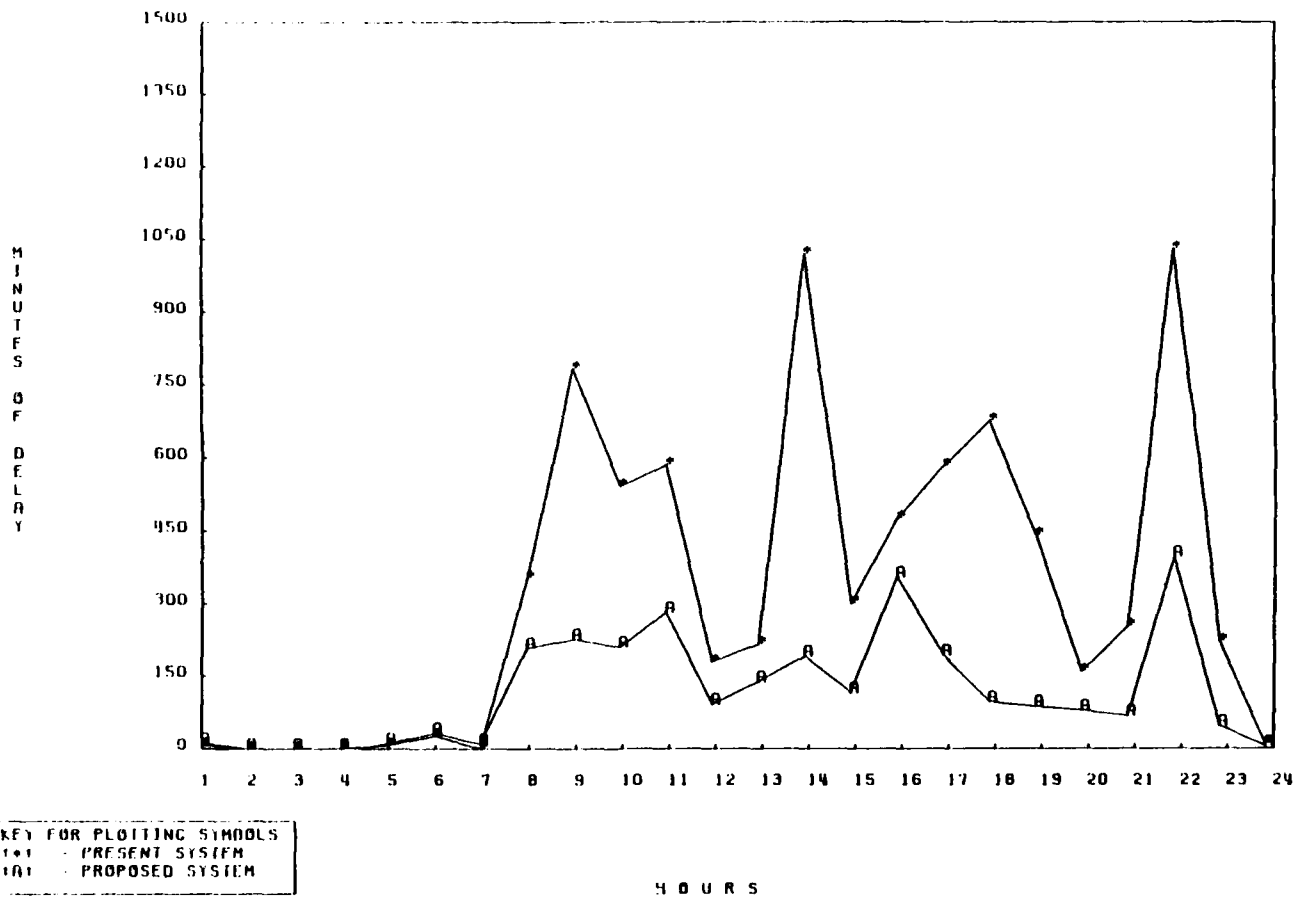


EXHIBIT 5

ST LOUIS TOWER - KANSAS CITY CENTER  
 DATA BASE NOVEMBER 21, 1979  
 24 HOUR DELAY PROFILE - INCREASED DEMAND 40%

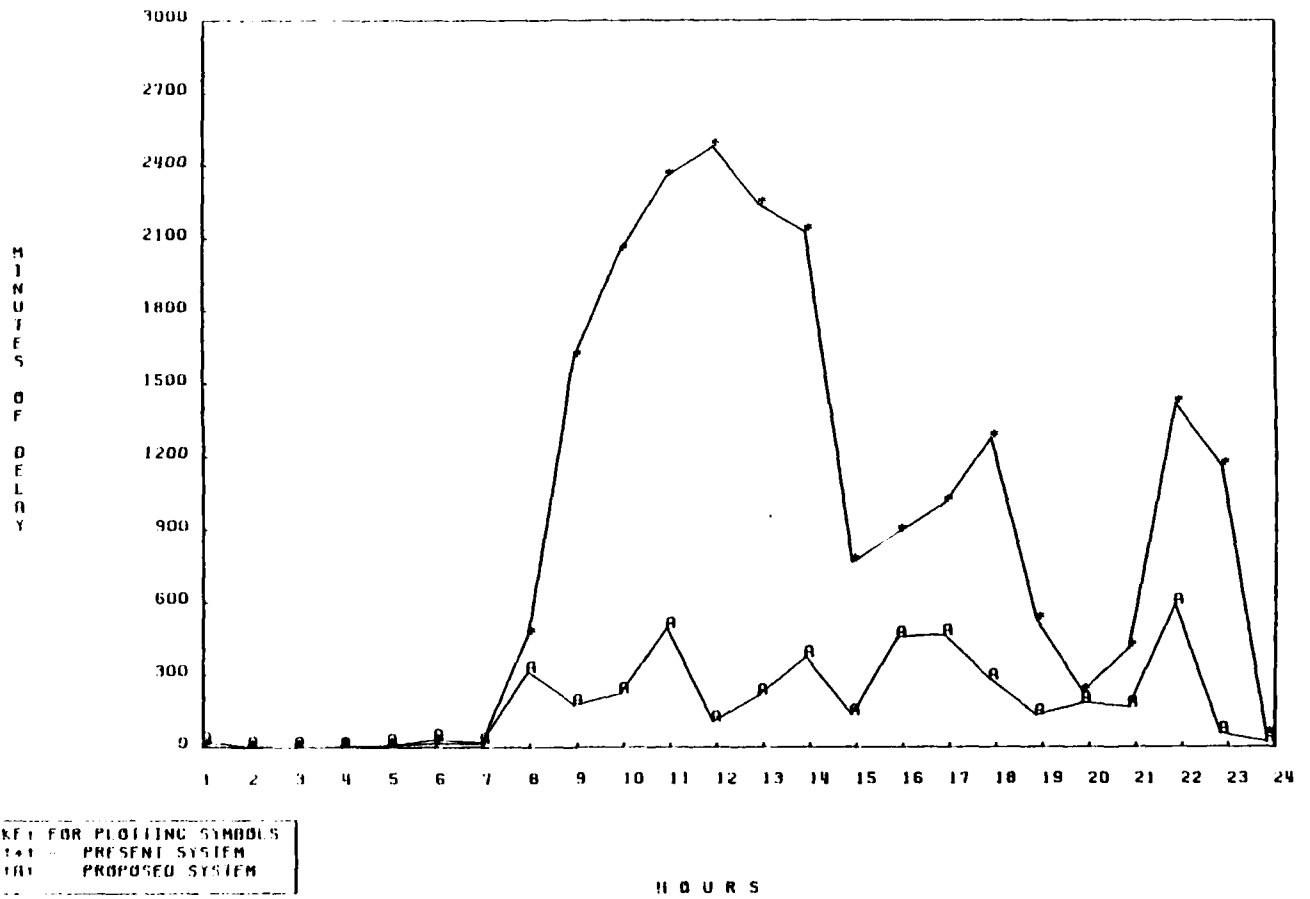


EXHIBIT 6

#### AIR TRAFFIC OPERATING STRATEGY

Study group analyses found the following with respect to air traffic operating strategy:

- . St. Louis Runway 12R/L configuration, which for all practical purposes is identical to the runway 30L/R operation, was used as the basis for all simulation analyses. Runway utilization statistics indicate the following usage:

12R/L - 48%  
30L/R - 52%  
6/24 - 2%  
17/35 - 9%

Use of parallel visual approaches or simultaneous parallel ILS approaches (utilizing LDA Side-step approach) would decrease the level of arrival delays.

- . Utilization of runways 17/35, runway 17 in particular, for category A&B aircraft would increase the capacity of St. Louis-Lambert International Airport. However, these runways are not used for

landing and departures for the following reasons:

- a. Poor runway conditions have caused foreign object damage to aircraft.
- b. Pilot and controllers reluctant to utilize cross runway operations for simultaneous landings.
- c. Runway used as taxiway.

Resurfacing runway 17/35 (north of runway 12R/30L); improved operational procedures; controller training; and pilot education programs would enhance the use of runway 17 as a third arrival runway for general aviation and produce a noticeable trend toward reducing delays.

- . Demand balancing of arrival fixes to balance terminal controller workload is inefficient and penalizes users unnecessarily. Delay could be reduced by improving internal coordination equipment and procedures.



- Airspace constraints account for 80% of the present total system delay (\*), with terminal departure airspace delay contributing 53% and arrival/over traffic airspace contributing 27%. The remaining 20% of the total delay is attributable to runway limitations.

Reorganization of airspace jurisdictions, traffic flow and the addition of operating positions is the most significant contribution that can be made to reduce delay and accommodate increased demand.

\* Total system delay - Refers to that delay accumulated within the Kansas City ARTCC East Area enroute airspace below 18,000 feet msl, and within the St. Louis Terminal area.

- Major airspace bottlenecks - 56% of total system delay.

<u>Sector No</u>	<u>Operating Position</u>	<u>Total-D</u>	<u>Max-D</u>	<u>Ave</u>
6	STL South D/C	891	29	5
5	STL North D/C	516	13	3
15	ZKC Sector 54	511	36	7

- Reduced sector capacities are caused by many factors, including weather, traffic mix, and traffic flow restrictions. Departure flow restrictions are most common cause of reduced capacity, thus delays, in the airspace between St. Louis Airport and the Indianapolis and Memphis Center control boundaries. It appears the close proximity of these boundaries to St. Louis and the speeds of turbojet aircraft leave insufficient time for the receiving control facility to assimilate, review and process high levels of activity into their traffic management function. Therefore, it is suggested to eliminate the time constraint by reversing the traffic flow; i.e., arrive via BIB-TOY and depart

on either side of this routing, Kubick-VLA and Burck-ENL. Such action would provide an additional departure routing and help relieve present congestion. Fig. 2

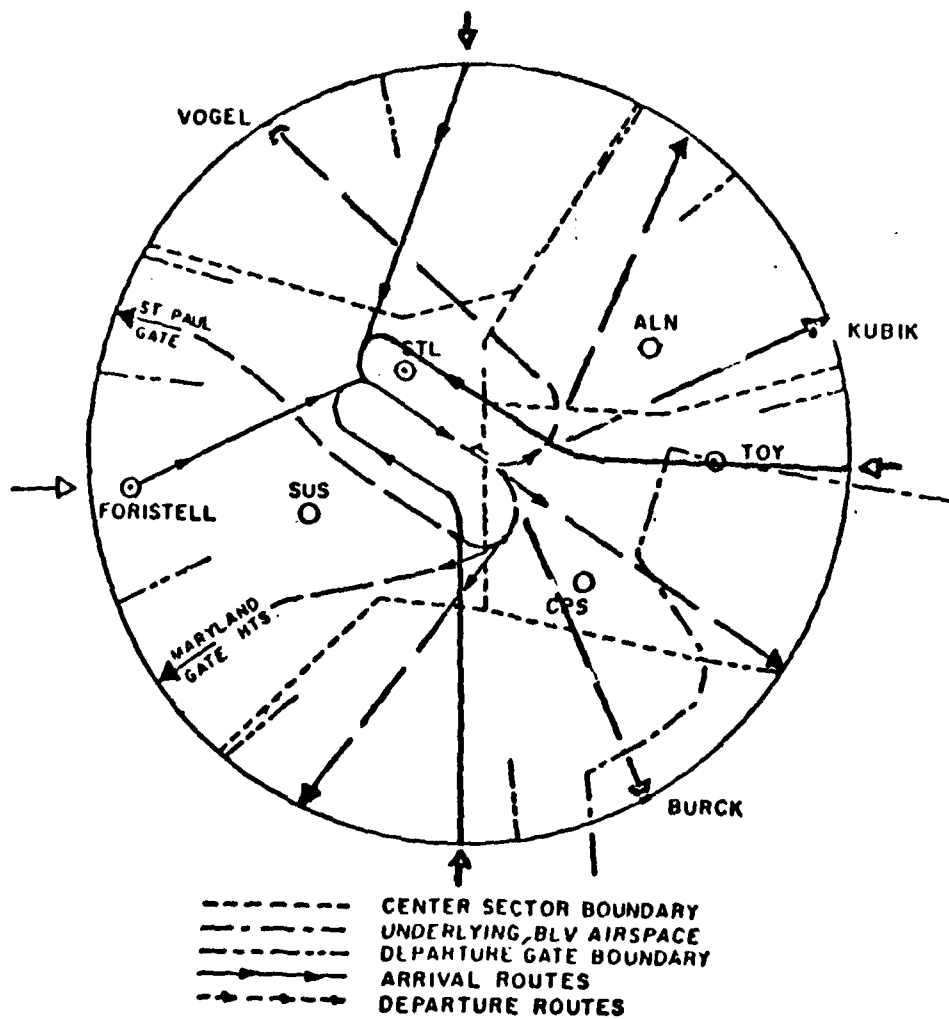
- Reliance on radar control for navigation and to monitor separation, primarily to accommodate pilot preferred altitudes, especially in enroute sectors below 18,000 feet is limiting system growth and causing delays. Radar control is limited by human capacities using non-radar procedures. Emphasis should be placed on the use of conflict resolution and/or to establish initial separation.

#### MANAGEMENT OF DEMAND

Congestion delays beyond those related to limited airspace and airport capacity are due to demand. This section summarizes the findings and recommendations from analyses directed toward reducing congestion delays through limiting or controlling peak demand at St. Louis-Lambert Airport:

- Scheduling practices and associated preferred routings have inherent delays beyond the short-term resolution prerogatives of air traffic control. For example, the eastbound Troy departure gate bottleneck has long been identified as a major source of delay, but little, if any, action has been taken to avoid this routing during peak departure periods. It is not uncommon to observe ten (10) airline aircraft belonging to the same company, taxi virtually, at the same time, routed vice Troy departure gate. If flow restrictions permitted minimum spacing (5nm) and aircraft were launched at one minute intervals, the tenth

FIGURE 2  
PROPOSED TRAFFIC FLOW



aircraft would be delayed nine (9) minutes and the accumulative total delay would be 45 minutes. Since the normal flow restriction is 10 miles intrail for most of these aircraft, the actual delay is much higher.

In the short term, or until the system constraint is removed, it would behoove airlines to consider trading route mileage penalties for ground delay reductions.

When low and high performance aircraft are required to operate in the same airspace and on the same runway during relatively the same time periods, high performance aircraft are subjected to delays. These delays are due to incompatible airspeeds and the additional separation that is required behind low performance aircraft to avoid overtake situations. St. Louis-Lambert International Airport will become more sensitive to the fleet mix with an increase in demand.

Current procedures for accepting category A & B aircraft arrivals

during peak periods should be discontinued unless such traffic can be accommodated on non-interfering runways.

Diverting category A & B aircraft to relieve airports indicate a 75% delay reduction at St. Louis-Lambert (i.e., from 1998 minutes to 503 minutes). However, this reduction is not a savings or reduction in total system delays, but rather a transfer of delay from one segment of the industry and/or airport to another. Further study to identify the full cost of diverting category A & B aircraft to reliever airports is required before such a recommendation could be supported by FAA.

### FACILITY IMPROVEMENTS

Several facility/airport development options were found to offer effective means to reduce delay.

- Providing Kansas City Center ARSR information to St. Louis Tower would allow approach control to establish a feeder-final concept, reaching out and picking up arrivals 50 nm from St. Louis Airport. Implementation of this concept would reduce inter-facility coordination, improve *traffic management* procedures to meet airport acceptance rates, and increase the efficiency of aircraft holding procedures.
- A short extension to runway 17 which would provide a non-interfering runway for category A & B aircraft would be justified by resultant delay reductions.
- Implementation of parallel approaches at St. Louis, through the adoption of the proposed LDA Side-step concept, will increase airport capacity during marginal weather conditions (ceilings between 2500

and 800 feet msl) and provide schedule operations with an airport dependability factor of 95%.

- A third departure control position and supporting procedures would remove the most significant bottleneck in the system. Complexity of the terminal area traffic flows with present and future demand levels suggest immediate action to keep traffic delays within manageable bounds.

### FUTURE ATC TECHNOLOGY

Six proposed FAA engineering and development elements have the potential to positively affect future operations at St. Louis-Lambert Airport. These technological advances, while identified as viable systems have not been quantified as to degree of impact upon our air traffic system. There is no attempt made at this time to evaluate their affect upon the current procedures/system at St. Louis Lambert Airport. These elements are:

1. Wake Vortex Advisory/Avoidance System (WVAS)
2. Upgraded automation - metering and spacing (MSS) and automation aids to the controller.
3. Discrete Address Beacon System (DABS)
4. Airport Surface Traffic Control (ASTC) - including Airport Surface Detection Equipment (ASDE) and Tower Automated Ground Surveillance (TAGS).

5. Area Navigation (RNAV) (in-being).
6. Micro-wave landing System (MLS).

The paragraphs which follow provide a brief description of each of these elements.

1. Wake Vortex Advisory/Avoidance System (WVAS) will provide increased capacity by reducing aircraft separation standards. Using the predictive data based on the life, decay and movement of vortices and meteorological conditions, the approach controller can establish aircraft spacing 5-15 miles from the runway threshold which reflect the expected vortex transport and decay conditions in the runway approach corridor. Two stages of development are envisioned:

Wake Advisory - Controllers will be provided with a display defining the applicable aircraft separation criteria for wake or no wake conditions.

Wake Avoidance - Aircraft spacing data will be provided directly to the ARTS III ATC equipment which

when combined with metering and spacing will provide highly automated sequencing and metering of aircraft arrivals automatically.

2. Upgraded Air Traffic Control Automation, whose principal element is metering and spacing. Additional aids will include computer controller aircraft routing and sequencing decisions, digitized displays of aircraft separations, transmission of aircraft control instruction to the pilot, computer generated alarms and MVAS information delays.

3. Discrete Address Beacon System (DABS) is an improvement of today's ATCRBS, intended to reduce the surveillance error and provide a ground-air-ground data link with the capability addressing each aircraft in a discrete manner.

4. Airport Surface Traffic Control (ASTC) is primarily oriented toward aiding the ground controller with improved automated displays using surveillance data and digitized displays. Two basic aids being developed are:

ASDE-3 - provides improved definition of aircraft surface traffic to the ground controller.

TACS which will provide a plan area display (PVD) of the airport with discrete aircraft identity tags.

5. Area Navigation (RNAV) is a ground derived airborne navigation system which will provide equipped aircraft with the ability to navigate along any course to any destination or to any intermediate way point.

6. Microwave Landing System (MLS) is intended as an extension of the current instrument landing system capability which provides precise azimuth, elevation angle and range data over a wide coverage volume. Provides the capability to define multiple final approach paths including curved approach capability.

#### DEMAND/DELAY RELATIONSHIPS

Future demand/delay relationships will be more complex than at present, consisting of different ATC operating procedures, not only for VFR and IFR weather but also for wake vortex and non-wake vortex conditions. The relationships between demand and delay were determined for both the pre-1985 and post-1985 time periods. The study findings are listed below:

- . The volume of unscheduled aircraft operations will have a significant influence on future St. Louis delay costs; the system performance appears more sensitive to fleet mix changes than to fleet volume changes.
- . If single and light twin propeller driven aircraft were diverted to reliever airports, a significant increase in the level of scheduled demand could be accommodated at St. Louis-Lambert International Airport.
- . As the percentage of heavy aircraft in the fleet increases, levels of delay greater than today's will be

experienced at the current level of scheduled demand, without a reduction in separation standards afforded by improved ATC equipment.

Under pre-1985 ATC equipment assumptions, delays will increase as a function of the maximum hourly operations scheduled.

Analyses indicate that with pre-1985 and post-1985 ATC equipment improvements the existing St. Louis airfield/airspace system will be capable of processing increased numbers of passengers through the post-1985 planning period. In pre-1985, seat capacity increases appear possible through volume increases in VFR and marginal weather. In the post-1985 environment, both increased volume and increased heavy aircraft concentrations appear possible at near current delay levels in all weather conditions.

Based on historical data, severe delay days may be expected to interrupt St. Louis operations during 38 days annually. These severe delay days are caused by



system disruptions resulting from:

- a. Weather
- b. Navigational aid malfunctions
- c. Runway closures due to disabled aircraft
- d. Runway closures due to construction and maintenance

Knowledge of such disruptions and their repetitive nature, dictate that procedures be refined for controlling traffic flow into the St. Louis Terminal system under conditions of severe delays.

In consort, the airlines should develop an effective and equitable plan for consolidation or cancellation of flights during short term reduced capacity conditions at St. Louis.

#### ACTION PLAN

The previous sections have summarized the major findings, conclusions and recommendations of the Delay Study Group. Implementation of many of the potentially effective delay reduction actions identified will require further intensive effort and action on a joint or individual basis by group participants. This section presents an action plan which identifies the type of action recommended, the action priority, and the agency responsible for initiation of follow-through. If implemented, the action plan outlined will result in the delay savings described throughout this report. The action plan identifies four types of actions as follows:

- . Implementable Items - Changes or improvements whose benefits have been clearly identified and do not necessitate a major policy change by any of the study participants.
- . Major Policy Items - Changes in procedural or regulatory environment requiring major policy changes by one of more study participants.

- . Air Traffic Control System Items -  
Improvements whose character requires  
that they be system-wide in application,  
necessitating further evaluation and/  
or research and development by the  
Federal Aviation Administration.

The time frame for each item of the action plan along with a recommendation for the lead responsibility for follow-through on each item are indicated in the tabulation which immediately follows. The elements in each group are listed in order of recommended implementation priority. It is stressed that the responsibilities shown provide identification of the lead-agency in the most appropriate position to initiate action on each item; with few exceptions all groups will be required to actively participate in accomplishing each action.

# RECOMMENDED ACTION PLAN

ACTION	TIME FRAME			LEAD AGENCY	
	SHORT	INTERMEDIATE	LONG	FAA	AIRLINES
IMPLEMENTABLE ITEMS					
Utilize one additional departure position	X			X	
Utilize two additional arrival/center positions	X			X	
Develop an airline delay reporting system	X				X
Minimize configuration shifts in peak demand periods	X	X	X	X	
Segregate aircraft by weight (12500 #) whenever practical	X	X	X	X	
Operate in delay optimal configurations	X	X	X	X	
Assume IFR control of Scott AFB Air Traffic Area	X	X		X	
POLICY ITEMS					
Develop and implement an airspace reorganization plan	X			X	
Develop a plan to consolidate or cancel flights during anticipated conditions of reduced capacity at St. Louis-Lambert International Airport	X	X			X
Employ quantitative techniques in all future planning work	X	X	X	X	X

ACTION	TIME FRAME			LEAD AGENCY	
	SHORT	INTERMEDIATE	LONG	FAA	AIRLINES
ATC SYSTEM ITEMS					
Increase effort on wake vortex and metering and spacing equipment	X	X		X	
Conduct airspace analysis to determine interaction between St. Louis, Kansas City Center, Chicago Center and Indianapolis Center	X	X		X	
Remote STL ARSR in St. Louis Approach Control Building	X	X		X	
Define flow control procedures for controlling St. Louis traffic under anomalous demand	X			X	
Increase development efforts for M/S program	X			X	
Determine feasibility of segregating military and civil aircraft at St. Louis	X	X		X	

END

DATE  
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